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CHARACTERISTICS AND SAMPLING EFFICIENCIES OF OMNI 3000 AEROSOL SAMPLERS

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14. ABSTRACT
Characteristics and aerosol sampling efficiencies of four Omni 3000 aerosol samplers (Sceptor Industries, Inc., Kansas, MO) were determined at ECBC. These samplers have nontraditional wetted-wall cyclones to collect and concentrate aerosols into liquid. The sampling efficiency tests were conducted with monodisperse 0.5-, 1-, 3-, and 5-µm fluorescent polystyrene latex (PSL) microsperes and 2.9-, 5.8-, and 8-µm fluorescent oleic acid particles. The results showed the highest sampling efficiency of 91% for 3-µm particles using the fluorescent PSL microspheres and 70% for 2.9-µm liquid fluorescent oleic acid particles. Omni aerosol samplers have approximately 277 L/min of air flowrate, use 83 W of power, depending on the attachments, and they are small in size. They give approximately 11 mL of liquid after each sampling. These samplers are portable, battery operated, and easy to use and decontaminate.

15. SUBJECT TERMS

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Aerosol	Aerosol samplers	Wetted-wall cyclone

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PREFACE

The work described in this report was authorized under Project No. 62262255200, Non-Medical CB Defense. The work was started in February 2006 and completed in March 2006. The data are recorded in Laboratory Notebook No. 04-0060, pages 104-121.

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CHARACTERISTICS AND SAMPLING EFFICIENCIES
OF OMNI 3000 AEROSOL SAMPLERS

1. INTRODUCTION

This technical note is one in a continuing series of short reports intended to document and preserve the record of data from characterizing aerosol samplers/concentrators. This report is not intended to be a comprehensive study or analysis. A technical note simply records a limited set of observations, offers some preliminary analysis and, if appropriate, provides the company that provided the device with a record of the data measured. Results of more thorough studies may be found in technical reports.

Air samplers/concentrators and detectors are important in the war against terrorism and on the battlefield to detect the presence of chemical, biological, and nuclear aerosols. Samplers/concentrators and detection systems must be evaluated and their performance efficiencies determined so that suitable samplers and detectors can be used. Knowledge of equipment performance enhances the ability to protect soldiers, first responders, and the general public. An ideal aerosol concentrator should be small, portable, use minimal power, and have a high concentration efficiency.

Some aerosol samplers are designed to collect bioaerosols in liquid to preserve the viability of organisms, and wetted-wall cyclones, such as Omni 3000, collect aerosols in this manner. In this study, the characteristics and sampling efficiencies of four Omni 3000 aerosol samplers were characterized. Omni 3000 is manufactured by Sceptor Industries, Inc. (Kansas City, MO). In addition, characteristics (e.g., dimensions, power, and air flowrates) of these samplers were also measured.

2. EQUIPMENT AND FACILITIES

2.1 Chamber.

The tests were conducted in a 70-m^3 biosafety Level 1+ chamber (Figure 1) at the U.S. Army Edgewood Chemical Biological Center (ECBC). Chamber temperature and humidity can be set and maintained easily and accurately by a computer. The computer also controls power receptacles inside the chamber.

HEPA filters are installed at the air inlet to filter the air entering the chamber to achieve very low particle concentrations in the chamber. Similarly, HEPA filters are also installed at the exhaust port to filter particles leaving the chamber. The aerosol concentration in the chamber is reduced by exhausting chamber air through the HEPA filters, and by pumping HEPA-filtered air into the chamber. The maximum amount of airflow that can be exhausted from the chamber is approximately 700 ft^3/min (approximately 2 x 10^4 L/min). There is also a small re-circulation system that removes air from the chamber, passes it through a HEPA filter,

and delivers it back to the chamber. This system is useful when the aerosol concentration in the chamber needs to be reduced by a small amount.

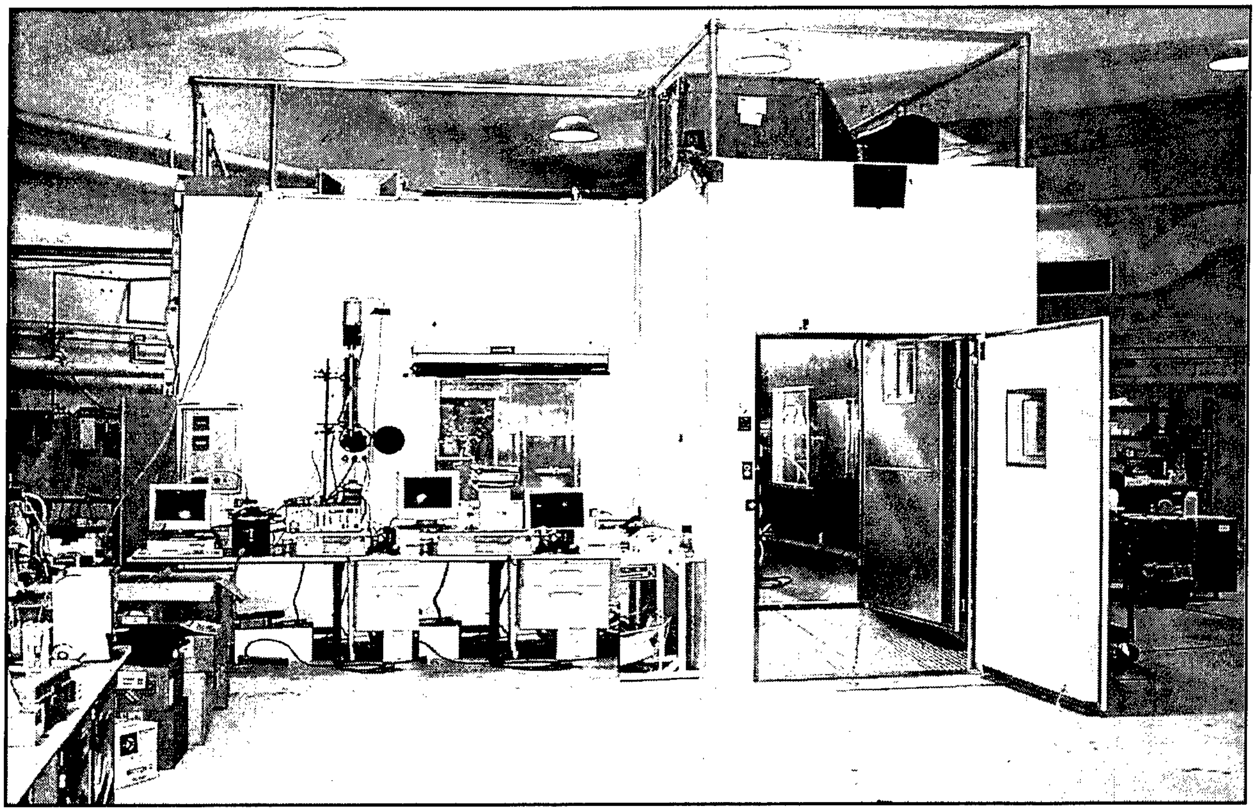

Figure 1. 70-m^3 Aerosol Chamber at ECBC

Aerosols can either be generated outside and delivered to the chamber, or they can be generated inside the chamber. A fan mixes chamber air before and/or during the experiment to achieve uniform aerosol concentration in the chamber. Previous tests show that mixing the aerosol in the chamber for 1 min is adequate to achieve uniform aerosol concentration.

2.2 Omni 3000 Aerosol Sampler.

The Omni aerosol sampler is a nontraditional wetted-wall cyclone designed to sample at an air flowrate of 300 L/min. This is a portable sampler for indoor and outdoor applications. This sampler is designed for portability, ease of use, low maintenance, and user safety. A picture of an Omni aerosol sampler is shown in Figure 2, and the sampler characteristics are given in Table 1. Air enters the glass contactor through two narrow slits in the contactor. The unit retains the water in the cyclone and does not produce a continuous liquid output stream. Sample volume is independent of sampling time.

The sample is contained in the sample cartridge that pulls out for easy handling, and the operator does not come in contact with the liquid. A liquid pouch is placed inside the sampler. It adds liquid to the cartridge as water evaporates during sampling. An air filter may be connected to the exhaust of the sampler in situations where all the particles entering the sampler need to be captured. One advantage of the Omni aerosol sampler is that it is easy to decontaminate inside and outside.

This sampler can operate on battery and on external 120 V ac. The system uses 24 V dc Hot Swappable Nickel Metal Hydride batteries. The manufacturer states that this sampler can operate in temperatures of 36-120 °F. The sampling time can be up to 6 hr. The sample output is designed to be approximately 10 mL.

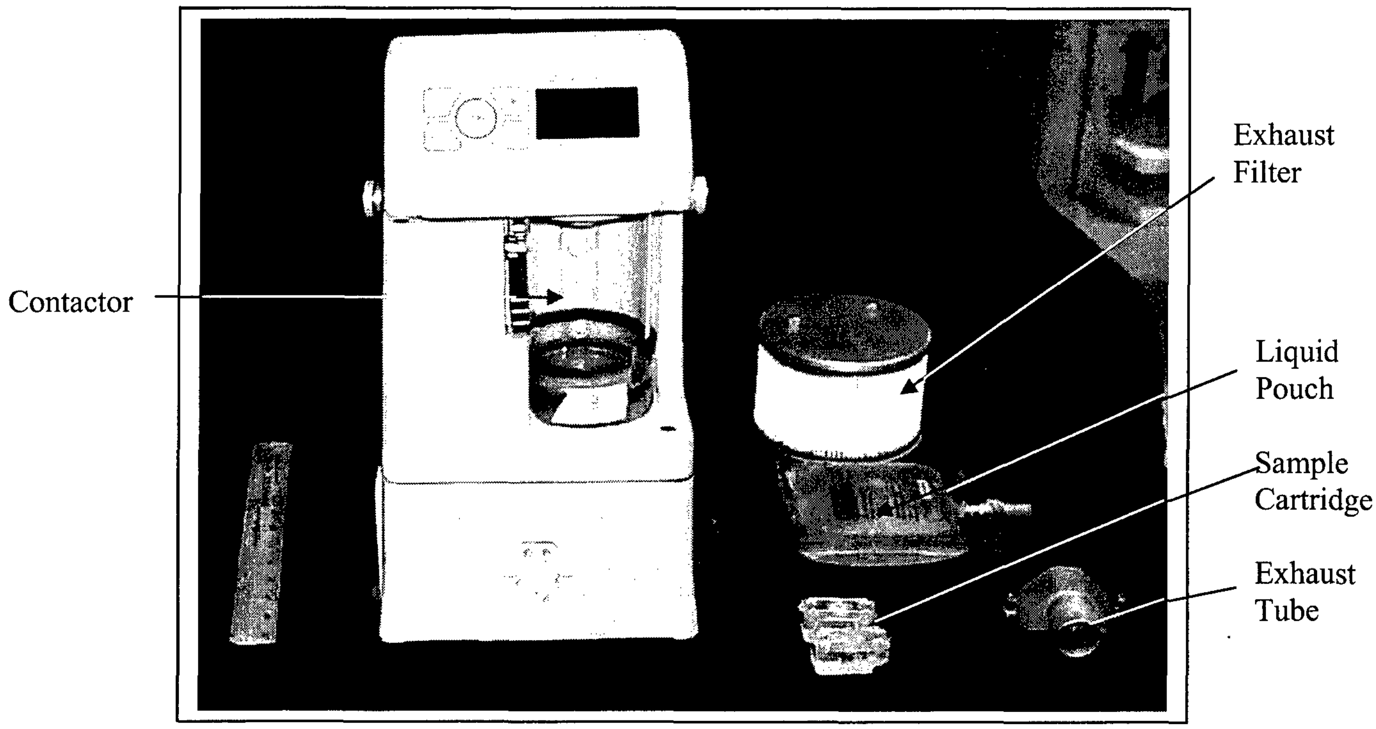

Figure 2. Omni 3000 Aerosol Sampler

Table 1. Characteristics of Omni 3000 Aerosol Samplers

	Omni 1	Omni 2	Omni 3	Omni 4
Serial No.	34	26	29	35
Air Flowrate, L/min	268	286	277	278
Power (W)	83.7		74	91.7
PF/VA	1	Not	1	1
Volts	119.2	Measured	119.4	119.8
Current	0.7		0.6	0.8
Weight (lb)				
without battery	14	14	14	14
with battery*	< 21	< 21	< 21	< 21
Dimensions (in.)	L - 8.5	L - 8.5	L - 8.5	L - 8.5
	W - 7	W - 7	W - 7	W - 7
	H - 17	H - 17	H - 17	H - 17
Sample Volume, mL				
Fluorescent PSL tests	11.1 ± 0.7	10.7 ± 1.1	11.4 ± 0.8	11.8 ± 1.4
Fluorescent oil droplets	11.1 ± 1.0	11.4 ± 0.3	11.7 ± 0.4	12.0 ± 0.3

* The units tested ran on 120 V ac power and were not provided with batteries. The manufacturer's literature claims that the weight with batteries is <21 lb.

2.3 Sampler Characteristics.

A mass flow meter (4000 Series, TSI Inc., St. Paul, MN) and Kurz airflow meter (Kurz Instruments, Inc., Monterey, CA) measured the air flowrates of the reference filters and samplers. The air flowrates, power, weight, and dimensions of the samplers are listed in Table 1.

3. TEST PROCEDURES AND ANALYSIS

3.1 Sampling Efficiency Measurements.

The sampling efficiency tests were conducted with two kinds of aerosols and corresponding analyses methods. The first method used monodisperse 0.5-, 1-, 3- and 5-μm fluorescent polystyrene latex (PSL) microspheres, and the second method used monodisperse

2.9-, 5.8- and 8-µm fluorescent oleic acid particles. The samplers and the corresponding reference filters sampled the air simultaneously. The aerosol generation and analysis methods are described in detail in Sections 3.2 and 3.3.

3.2 PSL Tests.

Sampling efficiency tests were conducted with 0.5-, 1-, 3- and 5-µm fluorescent PSL microspheres (Duke Scientific Corp., Palo Alto, CA). The PSL aerosols were generated using a 24-jet Collison nebulizer and then passed through a radioactive isotope (Kr-85) neutralizer to reduce the charge on the particles. The PSL aerosol was delivered into the 70-m^3 chamber. The samplers and reference filters were placed in the chamber. The aerosol was generated for 10-20 min and mixed before sampling.

The samplers and the corresponding reference filters sampled the PSL aerosol simultaneously and for the same amount of time. Polycarbonate membrane filters (Osmonics, Inc., Minnetonka, MN) were used as reference filters to collect the fluorescent PSL microspheres. After sampling, the samples were collected from the samplers and reference filters. Removing particles from membrane filters consists of placing the membrane filters into 20 mL of filtered deionized water, shaking the mixture by hand for 10 s, and then vortexing the mixture for 50 s. The hand shaking and vortexing were repeated four more times for a total of 5 min.

3.3 Sodium Fluorescein Tagged Oleic Acid (Fluorescent Oleic Acid) Tests.

Sampling efficiency tests were also conducted with 2.9-, 5.8-, and 8-µm fluorescent oleic acid particles. The monodisperse fluorescent oleic acid particles were generated using a Vibrating Orifice Aerosol Generator (VOAG, TSI Inc., St. Paul, MN). As with the PSL tests, the generated aerosol was passed through a Kr-85 radioactive isotope neutralizer to reduce the charge on the particles, and then delivered to the chamber. The sizes of the fluorescent oleic acid particles were determined by sampling the aerosol onto a microscope slide inserted into an impactor. Then, the droplet size was measured with a microscope. A microscopic picture of fluorescent oleic acid droplets on a slide is shown in Figure 3. The measured fluorescent oleic acid particle diameter was converted to an aerodynamic particle size using a spread factor (Olan-Figueroa et al., 1982)[1] and density. At the end of aerosol generation, the aerosol in the chamber was mixed for 1 min before sampling. The samplers and the corresponding reference filters sampled the aerosol simultaneously and for the same amount of time. Glass fiber filters (Pall Corporation, Ann Arbor, MI) were used as reference filters to collect fluorescent oleic acid particles.

The glass fiber filters were removed from the filter holders, placed into a fluorescein recovery solution, and shaken on a table rotator (Lab-Line Instruments, Inc., Melrose Park, IL) for 1 hr. The recovery solution used in these tests had water and alcohol with a pH between 8 and 10, obtained by adding a small amount of NH_4OH (e.g., 999 mL of water with 1 mL of 14.8 N NH_4OH).

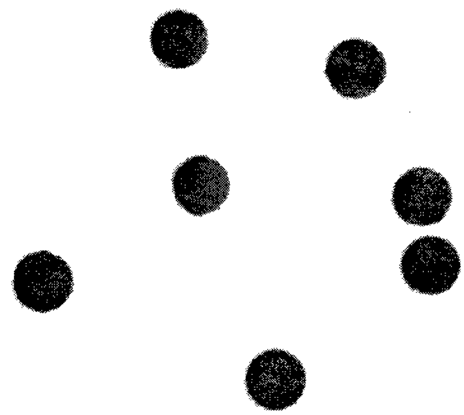

Figure 3. Microscopic Picture of Fluorescent Oleic Acid Droplets

Factors that affect fluorescein analysis and the removal of fluorescein from filters are described in detail by Kesavan et al. (2001).[2] The fluorescence of the solution was measured using a fluorometer. All the samples were analyzed either the same day as the experiment or the next day.

3.4 Analysis.

The sampling efficiency was determined by comparing the amount of fluorescent material collected by the sampler and the reference filters. The air flowrate of the sampler and reference filters, and the liquid volume of the samples and reference solutions were considered in the calculation.

The concentration efficiency was calculated using the following equation:

$$\text{Sampling Efficiency} = \frac{\left[\dfrac{(\text{fluorometer reading of sampler}) \times (\text{liquid volume})}{(\text{air flow rate})}\right]}{\left[\dfrac{(\text{fluorometer reading of reference filter}) \times (\text{liquid volume})}{(\text{air flow rate})}\right]} \times 100\,.$$

4. RESULTS

The sampler characteristics and sampling efficiency results are summarized in Tables 1 and 2. The sampling efficiency graphs for four Omni aerosol samplers are shown in Figure 4. The results show that the highest sampling efficiency is for the 3-µm particles, and that it decreases for smaller and larger sizes. The sampling efficiencies of liquid particles are lower than similar-sized solid particles.

Table 2. Average Sampling Efficiency of Omni 3000 Aerosol Samplers

Particle Size (μm)	Particle Type	Sampling Efficiency (%)			
		Omni-1	Omni-2	Omni-3	Omni-4
0.5	PSL	37.8 ± 2.7*	34.7 ± 3.7	36.1 ± 1.9	34.0 ± 5.0
1.0	PSL	44.0 ± 9.3	43.1 ± 6.4	Not run	41.2 ± 10.7
3.0	PSL	91.7 ± 1.9	89.1 ± 1.6	91.8 ± 0.7	90.6 ± 2.5
5.0	PSL	90.8 ± 2.7	88.0 ± 4.3	92.3 ± 5.2	Not run
2.9	Oil	66.6 ± 5.6	Not run	74.3 ± 7.1	67.1 ± 5.6
5.8	Oil	30.8 ± 5.9	58.8 ± 13.4	58.8 ± 3.0	48.3 ± 1.8
8.0	Oil	21.7 ± 2.6	Not run	34.4 ± 4.0	30.8 ± 2.3

* mean ± std

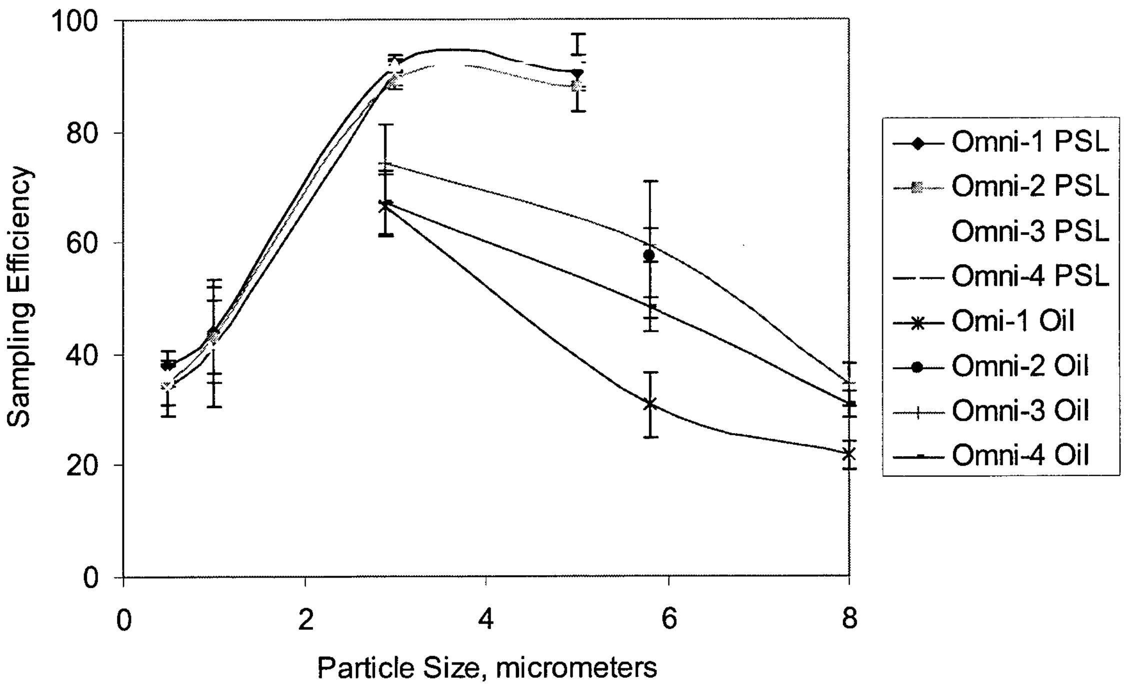

Figure 4. Sampling Efficiency of Omni 3000 Aerosol Samplers

5. DISCUSSION

Characteristics and sampling efficiencies of four aerosol samplers were determined at ECBC. These samplers were only available for 2 weeks of testing. Therefore, the particle sizes and number of tests conducted were limited. Sampling efficiency was determined using 0.5-, 1-, 3-, and 5-µm PSL microspheres and 2.9-, 5.8-, and 8-µm oleic acid particles. All four samplers had similar sampling efficiency curves for PSL microspheres; however, the sampling efficiencies of liquid particles were different. The highest sampling efficiency was 91% for 3-µm PSL microspheres and 70% for 2.9-µm liquid fluorescent oleic acid particles. Sampling efficiencies of fluorescent oleic acid results were lower than the solid PSL microsphere results. This was observed in previous tests with Omni and SpinCon aerosol samplers. This may be due to liquid particles getting removed from air when they impact on walls and on the slit and not reaching the inside of the contactor, compared to PSL particles that bounce off surfaces.

The Omni aerosol samplers delivered similar volumes of liquid during the sampling of fluorescent PSL microspheres and fluorescent oleic acid particle. The SpinCon is a similar type of aerosol sampler previously developed by the same manufacturer and tested at ECBC (Kesavan and Schepers, 2006).[3] Previous SpinCon test results show a reduction in liquid volume during fluorescent oleic acid tests. This was due to the SpinCon's infrared photosensor that controls the liquid volume being affected by the fluorescent oleic acid aerosol. However, this is not seen in the Omni aerosol samplers because the pressure differences control the liquid level in the contactor.

6. CONCLUSIONS

Four Omni 3000 model aerosol samplers were characterized at the U.S. Army Edgewood Chemical Biological Center (ECBC) using 0.5-, 1-, 3-, and 5-µm polystyrene latex (PSL) microspheres and 2.9-, 5.8-, and 8-µm oleic acid particles. Sampler characterization results show that Omni aerosol samplers have approximately 277 L/min of airflow, use 83 W of power, and they are small in size. They give approximately 11 mL of samples after each sampling. For all four samplers, the highest sampling efficiency of 91% was determined for 3-µm PSL microspheres and 70% for 2.9-µm fluorescent oleic acid particles. These samplers are portable, battery operated, and easy to use and decontaminate.

Many samplers are characterized at ECBC, and the results are published in technical notes. When considering a sampler for an application, the decision should include information on sampling efficiency, concentration factor, sampler size, weight, airflow, pressure drop (not measured in this study), and power consumption. Readers are advised that these samplers may be modified and/or improved based on our tests, and may be improved as new technology becomes available. Therefore, a modified or improved sampler may have very different characteristics than those discussed in this technical note.

LITERATURE CITED

1. Olan-Figueroa, E.; McFarland, A.R.; Ortiz, C.A. Flattening Coefficients for DOP and Oleic Acid Droplets Deposited on Treated Glass Slides. *Am. Ind. Hyg. Assoc. J.* **1982**, *43*; pp 395-399.

2. Kesavan, J.; Doherty, R.W.; Wise, D.G.; McFarland, A. *Factors That Affect Fluorescein Analysis*; ECBC-TR-208; U.S. Army Edgewood Chemical Biological Center: Aberdeen Proving Ground, MD, 2001; UNCLASSIFIED Report (AD-A397 677).

3. Kesavan, J.; Schepers, D. *Characteristics and Sampling Efficiencies of SpinCon and Pre-Production Omni Model Aerosol Samplers*. ECBC-TN-027; U.S. Army Edgewood Chemical Biological Center: Aberdeen Proving Ground, MD, 2006; UNCLASSIFIED Report.